CHEMICAL SOCIETY'S MEMORIAL LECTURES.

AT an extra meeting of the Chemical Society, held on December 13 last, this being the first anniversary of the death of Stas, a paper was read and discussed which had been prepared for the occasion by Prof. J. W. Mallet, F.R.S., of the University of Virginia, U.S.N.A.—himself a high authority on atomic weight determinations, and well known to chemists through his papers on the atomic weights of aluminium and gold, published by the Royal Society of London.

The lecture marks a new departure in the work of the society. Hitherto our learned societies have been in the habit of publishing more or less complete—it would probably be nearer the truth to say incomplete—obituary notices of their foreign members. The Chemical Society has come to the conclusion, however, that inasmuch as its foreign members are always men of great distinction who, as a rule, have lived a considerable number of years after accomplishing their life work, it will be to the advantage of its fellows and of chemists generally, if the obituary notices of foreign members take the form of critical monographs of the subjects with which they have principally dealt.

The anniversary of the death of the foreign member is obviously the most appropriate occasion for the delivery of such a lecture. During the past year the society has lost two of its foreign members: Hermann Kopp, noted as an historian, as well as on account of his very numerous exact determinations of atomic volumes and specific heats, and A. W. von Hofmann. The life and work of the first mentioned will form the subject of a lecture to be delivered on February 20 next, by Prof. Thorpe, the Treasurer of the Society, than whom no one is more qualified to undertake the task. Prof. Thorpe is not only a pupil of the deceased chemist, but has reverently followed in his footsteps—having very largely extended Kopp's observations on atomic volumes in an elaborate investigation, the importance of which was recognised by the Chemical Society in 1881 through the award to him of its first Longstaff medal.

Von Hofmann, although originally a foreign member, became an ordinary member of the Chemical Society on coming to England as professor at the school in Oxford Street, long since merged in what is now known as the Royal College of Science, London. Hofmann was never again regarded as a foreigner; he served the society both as foreign secretary and as president, filling one of the vice-chairs during the remainder of his life. It is felt that owing to the special nature of his relations to the society and to english chemistry, it will be necessary to deal with his case in an exceptional manner; it is therefore hoped that in May next Lord Playfair—who was so intimately connected in his early days with chemical science and with the society—in the first place will picture the state of affairs chemical at and prior to the time of Hofmann's arrival in England. Sir F. Abel, Hofmann's first pupil and assistant, will follow with an account of Hofmann at the Royal College of Chemistry, calling to his aid for this purpose the remaining friends and pupils of Hofmann. The coal-tar colour industry, which has now attained such important dimensions, it is well known, had its origin in the Oxford Street laboratory, and Dr. Perkin—its parent—has consented to sketch the history of its development. In this manner it is hoped to impart considerable "local colour" to the Hofmann memorial lecture, thereby distinguishing it from the notice which is being prepared by the German biographers.

Passing now to Prof. Mallet's lecture on Stas, which is of considerable length, as it will occupy fully sixty pages in the Society's Journal. The biographical portion is brief, as a number of such sketches have already been published. Stas was born at Louvain on August 21, 1813. He graduated as Doctor of Medicine. His taste for chemical research was evidenced in 1835, when, together with a friend, he investigated in an attic of his father's house the crystalline substance phloridzin which they had extracted from the root bark of the apple tree. He continued the study of this substance in Dumas' laboratory in Paris, and it is an interesting proof of the acumen of Berzelius that in his annual report on the progress of chemistry he referred to this first research made by Stas with praise, and a prediction of future eminence for the author.

The starting-point of the long train of research with which his name will ever be associated was the redetermination of the atomic mass of carbon which Dumas and he together undertook, in order to explain the fact, noticed by Liebig and others, that the sum of the carbon and hydrogen found in hydrocarbons by the combustion process, as calculated from the carbon dioxide and water, not unfrequently exceeded the quantity of material analyzed. As the result of this investigation, which was carried out with unprecedented care and the most elaborate precautions, the value hitherto accepted for carbon on the authority of Berzelius (76·432 O = 100) was considerably reduced (to 75·005). In 1840 Stas was appointed Professor in the École Royale Militaire at Brussels; he held this post for more than a quarter of a century, until an affection of the bronchial tubes and larynx obliged him to give up lecturing. He then received an appointment in the Mint, but resigned this in 1872 on political grounds, and withdrew into private life. He appears to have been a man of great independence of character.

Apart from his atomic weight investigations Stas did much work of value in other departments. His method of separating alkaloids from organic messes—no other name is applicable—which has been of such service in subsequent toxicological inquiries, was devised in 1850, in the course of the inquiry into the celebrated Bocarmé nicotine poisoning case. He examined into the methods of hydrolysing fats for the purpose of a report on the chemical section of the London 1862 Exhibition. In connection with the preparation of international standards he took an active part, along with Devile, in the inquiry into the properties of the platinum metals. It is known also that he did important work for his Government in investigating alloys for use in the construction of artillery.

Prof. Mallet prefaces his account of Stas's special investigations by an historical survey of the fundamental ideas which have gradually led up to the question, What is the mass of an atom of a particular element? Even in and beyond the days of Cavendish and Priestley the fact that atmospheric air was found of constant or nearly constant composition was long a stumbling-block in the way of clear distinction between a homogeneous compound and a uniform mixture. To the labours of Van Helmont, Boyle, and Boerhave much credit is due for the gradual advance towards the doctrine of the conservation of matter. The discoveries of Black and Cavendish brought it further into view, and it assumed its due importance and began to receive universal recognition with the constant appeal to the balance which Lavoisier made and taught others to make. Next came a comparison of the quantities of different substances, at first chiefly the then known acids and bases, which would enter into combination with each other. Proust, in the course of his controversy with Berthollet as to the fixedness of combining proportions, had observed that in certain cases it was true that in different compounds, consisting of the same constituents, for a fixed quantity of one constituent, the different quantities of another constituent bear to each other a simple multiple or sub-multiple relation. To Dalton, however, belongs the honour of announcing the principle as a general one, and of basing upon it a true chemical atomic theory of the nature of matter. Berzelius, in the early years of the present century, with apparatus in many respects inferior to that of the present day, and with scarcely any aid from chemical manufacturers in preparing pure materials and reagents, but with unsurpassed manipulative skill and the most honest criticism of his own work, produced the first fairly trustworthy list of numbers representing the proportions by weight in which the elements combine. Berzelius began work in this direction in 1807, his attention having been attracted by Richter's investigations; but soon afterwards he became acquainted with Dalton's new atomic theory of the nature of combination, and appears to have been impressed with its great importance, and at the same time with the need of more exact experimental data for its support and development. The wonderful accuracy of Berzelius's work generally is illustrated, as Prof. Mallet points out, by the fact that his number for oxygen, 16·021, becomes 15·894, almost exactly agreeing with the latest determinations of the present day, if the weighings of Dulong and Berzelius's three experiments on the synthesis of water be corrected for the buoyancy of the air. Since Berzelius many other chemists have worked in the same field, but his most worthy successor in such labours has undoubtedly been Stas. With greatly better resources in the way both of apparatus and material, with equal earnestness in seeking for the truth, with equal intelligence and skill he took up the task which became that of the largest part of his scientific life, and for a more limited list of elements than Berzelius had investigated, produced results of a degree of accuracy which it is high praise to say would have delighted no one more than Berzelius himself. He aimed at the determination with greater precision than any one before him had attained of the atomic weights of some ten or twelve of the elements. But by so determining these constants he endeavoured also to settle several general questions of fundamental importance in regard to matter as studied by the chemist.

Thus it has generally been assumed as true beyond dispute since the early part of the present century, that the mass of an atom of a given element is a constant quantity. This has, however, occasionally been doubted, and Stas himself considered the question as one requiring examination. His researches, however, lend no support to it. On this point Prof. Mallet expresses himself strongly in favour of the orthodox view.

Assuming that the atomic weights are immutable values, the question arises, Are they commensurable? This is the much-discussed hypothesis of Prout, the origin and development of which is very fully discussed by Prof. Mallet. A widespread feeling at one time undoubtedly existed among chemists that Prout's hypothesis, that the atomic weights of the other elements are integer multiples of that of hydrogen, if not true in its original form would ultimately prove to be so at least in a modified form. That Stas began his work under the influence of this feeling is clear from his own words:—

"Je le dis hautement lorsque j'ai entrepris mes recherches, j'avais une confiance presque absolue dans l'exactitude du principe de Prout."

But his experimental results clearly contradicted the hypothesis, and he satisfied himself that the atomic weights of the elements which he determined with such precision could not with truth be represented by integer multiples of the atomic weight of hydrogen, or the half or the fourth of this unit. In his own words:—

"Aussi longtemps que, pour l'établissement des lois qui régissent la matière on veut s'en tenir l'expérience, on doit considérer la loi de Prout comme une pure illusion. La simplicité de rapport de poids que présuppose l'hypothèse de Prout entre les masses qui interviennent dans l'action chimique, ne s'observe donc point dans l'expérience; elle n'existe point dans la réalité des choses."

The great majority of chemists—Prof. Mallet remarks—at the present day, are probably agreed in believing that the hypothesis of Prout has been shown by Stas to be untenable. But the fact that so many well determined atomic weights, referred to hydrogen as unity present numbers *nearly approaching integers*, is very striking and calls for further investigation. Stas himself is quoted as admitting this much. Prof. Dewar, in the course of the discussion after the paper was read, drew special attention to this question and gave several most striking instances of the nearer approach to whole numbers which resulted from a recalculation of the accepted values, using the lower value for oxygen (15·87) which so many recent researches tend to support, although on the other hand, of course, some of the values now near to whole numbers are considerably thrown out. Evidently there is ample opportunity for further experimental investigation of this all-important problem, and it is impossible—notwithstanding the extraordinary degree of accuracy attained by Stas—to formulate any final conclusion. The supreme interest attaching to the problem was clearly recognised by Stas himself, as the following words show:—

"Au point de vue de la philosophie naturelle, la portée de l'idée de Prout est immense. Les éléments des corps composés que nous considérons comme des corps simples en égard à leur immutabilité absolue pour nous, ne seraient eux-mêmes que des corps composés. Ces éléments, dont la découverte fait la gloire de Lavoisier et a immortalisé son nom peuvent être considérés ainsi comme dérivant de la condensation d'une matière unique: nous sommes naturellement conduits à l'unité de la matière, quoi qu'en realité nous constations sa pluralité, sa multiplicité."

This quotation is almost alone sufficient to show that Stas was a philosophical chemist of the highest order, and not a mere mechanical worker, as has sometimes been supposed; his unwearied attention to minutest details has undoubtedly served to completely overshadow the philosophical motives and aspirations by which he was guided.

Stas also endeavoured to obtain evidence with regard to the possible dissociation of the elements at high temperatures and to this end purified his materials with every imaginable precaution. The skill with which he carried out his operations is attested by the statement made by Mr. Crookes, the chairman at the reading of Prof. Mallet's paper, that he had seen in Stas's laboratory a large mass of potassium chloride, which Stas had been years in preparing, and in which he had failed to find a trace of sodium even spectroscopically—such an achievement appears almost inconceivable to the chemist. Stas, in fact, in the course of his work investigated the methods of analysis to be used with a degree of rigour, and discovered and applied refinements upon older methods of experiment with a degree of patience and skill, such as had never before been used in chemical investigation. Only those who are thoroughly conversant with such work can fully appreciate his labours; they probably will agree that owing to the multitude and diversity of the precautions to be taken, his work is the most difficult hitherto attempted, and that he stands unsurpassed among all who have undertaken the execution of exact physical measurements.

A lengthy section of Prof. Mallet's paper is devoted to the consideration of the objects to be aimed at and the methods to be pursued in future work. He advocates the repetition by competent hands of some one at least of Stas's fundamental results, calling attention to Stas's own emphatic expression of the wish that this should be done. It is also most important that no distinction should be made between rare and common elements, and that the atomic weights of all should be determined with the least possible delay and the highest attainable degree of accuracy. Certain of the elements particularly call for a more searching and exact investigation of their atomic masses, *e.g.* elements such as tellurium, which occupies a position in the periodic system not in harmony with its atomic mass, and cobalt, which plainly occupies the intermediate position between iron and nickel, and therefore should be intermediate in atomic mass.

In a number of cases the accepted value is based on the investigation of but a single interchange, the value for iron, for instance, being practically based on the results obtained on converting the metal into ferric oxide, and *vice-versâ*; and the relation of hydrogen to oxygen having been established by the reduction of cupric oxide. It is desirable that in such cases other and independent methods should be resorted to, *e.g.* that oxides of a number of metals other than copper should be reduced, with the object of detecting possible constant errors.

It is eminently desirable that an attempt be made to directly determine the ratio of hydrogen to each of the halogens without in any way bringing in the atomic mass of oxygen. Prof. Mallet suggests various methods deserving of study. Also it is very important that the metals of the yttrium and didymium groups should be further investigated. Prof. Mallet rightly terms the yttrium group the opprobrium of inorganic chemistry.

Nearly all that has been written hitherto in regard to the periodic relationship among the elements has involved the use of roughly approximate values only; but it is time that the foundation be laid for a more minute and critical study of the periodic system of classification. Anomalies in the classification as we now find it in our books, glimpses of more detailed relations than as yet clearly appear, tantalizing suggestiveness in so much of what is already before us, call for more precise determinations of the numbers we would discuss before we allow premature discussion to drift into mere fanciful speculation.

In regard to the methods which it is desirable shall be pursued in the determination of atomic masses, Prof. Mallet has much to say. He discusses the selection of processes, the purity of materials, the very numerous directions in which vigilance must be exercised in order to avoid extraneous or accidental causes of error, the quantities of material to be used, the practical precautions to be observed so as to secure accuracy of manipulation and in weighing and measuring, the mode of stating and calculating results, finally calling attention to the advantage to be derived from the application of greater working force and ampler means than can be commanded by private individuals to the determination of atomic masses; with reference to this last point, during the discussion on the paper, the opinion was freely expressed that it was undesirable that such work should be carried out in organized public or semi-public laboratories. The question is, no doubt, a difficult one to settle—such work demands a special temperament combined with genius of a high order and an infinite capacity for taking pains, qualities which must rarely occur united in a single individual. Moreover, in order that the value of a result may be appraised, it is essential to overlook every detail involved in the determination. Given the man, however, there can be no longer a doubt that every possible assistance he may require should be afforded him. It is marvellous that men like Berzelius and Stas, working all but alone and unaided, should have achieved results of such magnitude and universal importance—the moral effect of their example is certainly not less important than are the actual results of their labour.

The last section of Prof. Mallet's paper is devoted to the discussion of the form in which it is desirable finally to state the results. He here advocates the uniform substitution of the expression "atomic mass" for "atomic weight," on the ground that precision in language conduces to precision in thought—an aphorism far too commonly disregarded by chemists. We have now clear conceptions of atoms having constant mass for the same element, of determinable difference of mass in the case of different elements, the several masses and numbers of which regulate the composition of all known substances and the products resulting from interaction among them. The atomic theory has advanced far beyond the condition of a mere working hypothesis on which chemists long stood with more or less uncertain feet; but even if this were not so, considering it, to use a common metaphor, only as a scaffold, there is no good reason, so long as we stand on it and work from it, that we should be careless about tying our scaffold-poles and nailing our planks.

Lastly, Prof. Mallet urges that all atomic masses shall be expressed in terms of the mass of the hydrogen atom taken as unity, objecting strongly to the change to $O = 16$ which several writers have recently advocated, the most objectionable argument put forward in favour of such change being, he thinks, that the numbers we use are expressive of *ratios* only—that any figures are allowable which correctly express combining ratios, and that there are no reasons for using one set of figures rather than another save mere arithmetical convenience. This involves a grave error, as in adopting as unity the mass of a single atom of any particular element, preferably that one of which the mass is the smallest, we have reason to believe that we express the mass of all the others in terms of this as a really existent, definite, and constant quantity of matter. It is, indeed, difficult to understand when the scientific necessity in so many cases of taking hydrogen as the unit is realized, how the change to $O = 16$ can be advocated except on the simple utilitarian plea that it is to the analyst's convenience.

Prof. Mallet's monograph is undoubtedly a most admirable exposition of the philosophical lessons to be learnt from the contemplation of Stas's labours.

EXTINCT MONSTERS.[1]

THE volume with this title treats of large animals. It is clearly and simply written, without any pretence at being scientific, and is an excellent book for boys and unlearned people who are curious to be informed upon the subject of fossil animals. It would have escaped criticism altogether but for emphatic words of praise in the preface, and one or two passages in which the author, with second-hand information, speaks authoritatively of predecessors who restored extinct types of life with the slender materials which were available forty years ago. The attraction of the volume and its novelty is a series of restorations of saurians and mammals drawn chiefly by Mr. Smit. These for the most part are based upon the restorations of skeletons made by Prof. Marsh, whose discoveries have inspired Mr. Smit's pencil as much as they have influenced the author's pen. There is not much anatomy beneath the skins of the "Monsters," and they have an aspect as though cotton-wool had taken the place of muscle, or as though the drawings were models for the "Lowther Arcade." This, however, is of less importance than the answer given to the question, Are they reasonably faithful to nature? It does not seem to me that they can claim this merit; they are only reasonably faithful to Marsh. Prof. Marsh draws an animal so as to give one type the maximum height to which the bones can be hoisted; while another is given the maximum length to which the remains can be extended. My own studies would not have led me to reconstruct one of the extinct reptiles upon the lines which are adopted in

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[1] "Extinct Monsters." A popular account of some of the larger forms of ancient animal life. By Rev. H. N. Hutchinson, B.A., F.G.S., with illustrations by J. Smit and others. (London: Chapman and Hall, Ld., 1892.)